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NOTES FROM PACIFIC COAST OBSERVATORIES.

REPORT OF THE DIRECTOR OF THE LICK OBSERVATORY.

To the President of the University.

SIR: I have the honor to submit herewith my report for the period July 1, 1913, to May 31, 1914.

It is a pleasure to be able to say that a good start has been made in removing the arrears of publication. Volume VII, *Publications of the Lick Observatory,* containing papers by members of the Berkeley Astronomical Department, whose printing began in the year 1902, has now been completed. It was distributed to our correspondents in May, 1914.

Volume XI, *Publications of the Lick Observatory,* containing reproductions and brief descriptions of Professor BARNARD's Milky Way and comet photographs, is now in the binding stage in the State Printing Office, and we hope to distribute it to our correspondents in July or August, 1914. The cost of the plates, printing and paper for the 129 full-page illustrations was borne by subscriptions received from friends of the observatory, by Profesor BARNARD's personal contributions, and, to a minor degree, by funds taken from the Lick Observatory maintenance budget. The printing of the text and the binding of the volumes have proceeded on the basis of a Regents' appropriation.

In April, 1914, the Regents made a liberal appropriation in support of Lick Observatory printing, to become available on July 1, 1914. It is hoped that the printing of Volume XII, *Publications of the Lick Observatory,* to contain Mr. AITKEN's observations and studies of the more interesting visual double stars which he made during the years 1896-1913, may begin in July and proceed without interruption. The contents of this volume, thanks to the excellence of Mr. AITKEN's program of work and to his industry in following that program, will form one of the notable contributions to our knowledge of double-star systems.

We were planning that the reproductions of about one hundred photographs of Halley's Comet and of many representative solar eclipse photographs obtained by our expeditions in the years 1893, 1898, 1900, 1901, 1905 and 1908, might be secured this summer, preliminary to the publication of the photographs and accompanying texts in volume form. However, the appropriation does not become available until after the departure of Messrs. CAMPBELL and CURTIS for duty on the Crocker eclipse expedition to Russia; and as they are the ones directly interested in the securing of these photographs and in the examination of the engraver's proofs, the beginning of this work must be delayed until the fall months.

The improvements planned in 1913 by Mr. CURTIS for increasing the efficiency of the Crossley reflector, as described in my last annual report, were made in the latter half of 1913. All the manipulations necessary to the process of making observations with the reflector are now controlled electrically from the movable observing platform, so that the observer need not leave the platform during the work of an entire night. The relief from the fatigue and loss of time involved in the very numerous ascents and descents of the observing ladder under former conditions is very marked.

My last report referred pointedly to the fact that the 36-inch Crossley reflector, so well known from its important contributions to astronomical science, and still an exceedingly useful instrument, is rapidly becoming one of the smaller reflecting telescopes devoted systematically to research. A considerable number of reflecting telescopes, varying from forty-two to one hundred inches in diameter, are now in use by or under construction for other observatories. I respectfully repeat and urge that a responsibility rests upon those in authority to maintain the Lick Observatory in the advance rank of astronomical institutions. A reflecting telescope comparable in power with those now under construction elsewhere should be added to its equipment.

Extensive preparations have been made to observe the total solar eclipse of August 21, 1914, in continuation of observations secured at the favorable eclipses occurring since the opening of the Lick Observatory in 1888. Regent WILLIAM H. CROCKER has generously given the sum of $5,800 to defray the expense. Director CAMPBELL and Astronomer CURTIS will leave Mount Hamilton about June 10th, to establish the observing station in the vicinity of the city of Kiev, Russia. Twelve or more volunteer assistants, partly from this country and partly from Europe, will join the expedition to assist in the making of the photographs at the time of totality.

It has seemed to many astronomers that the time has come to determine the accurate positions of the fainter stars, say those fainter than the eighth visual magnitude, by means of photographs instead of by the prevailing meridian-circle visual method; reserving the visual method for extremely accurate observations of the brighter stars. The Allegheny Observatory is undertaking to apply the photographic method to a narrow zone of faint stars extending around the sky; and Professor TUCKER of our staff is securing the meridian-circle observations of six hundred of the brighter stars distributed uniformly thruout this zone, to form the skeleton, so to speak, upon which the positions of the fainter stars will depend. The four thousand individual observations required in our share of the program, and the computations related thereto, will consume the resources of our meridian-circle department during the current year. Twelve hundred and sixty of the observations have been secured by Mr. TUCKER since January 28th of this year.

In the prosecution of our double-star survey in the current academic year, Professor AITKEN has discovered 245 double stars, and has made accurate measures of 470 doubles. His discoveries to date number 2,845 pairs. Professor HUSSEY co-operated in the survey during the years 1899-1905, and discovered 1,328 pairs; making a total of 4,173 for the two observers. In essentially all of these pairs the two component stars are less than five seconds of arc apart. In the three-fifths of the sky thus far covered by the survey there are fewer than seven thousand such pairs as bright as the ninth magnitude.

Fully sixty per cent of all known double stars of this class in the region observed have been found in the progress of our survey. From Mount Hamilton the observations can be made to advantage as far south as declination — 14° for the winter sky and declination — 22° for the summer sky. In the area extending from the north pole of the sky to the southern limits just described, only 1,500 stars, or approximately one per cent of the whole number as bright as the ninth magnitude, remain to be examined. The work will be brought to a close before the end of the present calendar year. This double-star survey, which was begun by Mr. AITKEN in April, 1899, should be extended over the neglected southern hemisphere of the sky, by means of a suitably equipped expedition—a desideratum to which all astronomers cordially assent—and Mr. AITKEN is the logical observer for this duty. Financial conditions have prevented me from perfecting plans to this end.

Mr. AITKEN has given much time in the past year to preparing the data obtained from his double-star observations for a statistical study of the distribution and other characteristics of double stars. This work is in such form that the discussion for the northern sky can proceed promptly following the completion of the survey.

Mr. AITKEN has continued, as opportunity offered, the accurate observations of the well-known short-period double stars.

Professor WRIGHT has continued the work of photographing a large number of representative stellar spectra in order to illustrate very completely the great variety of spectral types. These photographs are taken in three sections, to insure that the entire available spectrum, from the ultra-violet to the red, may be recorded in sharp focus. It is proposed later to publish as many as possible of the results, to illustrate the apparent sequence of stellar evolution.

Mr. WRIGHT has completed his program of observations on the wave-lengths of bright lines in the spectra of the nebulæ, including the wave-lengths of many lines not noted by other observers. These observations are of special interest at the present time in connection with certain conceptions of the constitution of matter.

Mr. WRIGHT has continued his observations of the spectrum of the new star in *Gemini,* making them doubtless by far the most extensive observations of the new star that have been secured. An important paper on the subject is essentially ready for publication. The observations of new stars in the past generation have inclined astronomers to the view that they represent the results of some celestial catastrophe, such as the collision or close approach of two stars, or the passage of a star thru some form of resisting medium. However, these very detailed and accurate observations of the spectrum of *Nova Geminorum* seem to add complexity to the general problem of novæ.

Professor CURTIS has continued the photographic survey of the more prominent nebulæ, with the Crossley reflector. The descriptions of 109 such nebulæ were published by him recently. Mr. CURTIS has also been rephotographing many of the brightest spiral nebulæ which were photographed by Professor KEELER in the years 1898-1900. His purpose has been the important one of determining whether these objects have moved appreciably across the sky in the past fifteen years, or whether they have rotated thru appreciable angles in this interval. These questions concern vitally the greater one of whether the spiral nebulæ are to be regarded as a part of our own stellar universe or whether, as some astronomers have believed, they are separate universes of stars so remote from our universe that we see them merely as unresolved small areas of light.

The work of the D. O. Mills Expedition in the southern hemisphere has been vigorously prosecuted by Dr. WILSON and his assistants. The program has embraced the securing of many two-prism spectrograms of the stars between 5 and 5½ visual magnitudes; of one-prism spectrograms of the brighter stars whose spectra lines are too hazy for accurate measurement on the basis of two-prism dispersion; and of one-prism spectrograms for determining the radial velocities of the planetary nebulæ. Essentially all of the plates have been measured in duplicate. About twenty-five spectroscopic double stars have been discovered since the date of my last report; the greater number during the closing months of Dr. MOORE'S administration, which continued to August 9, 1913, and the remainder during Dr. WILSON's administration.

Messrs. MOORE and SANFORD have published an extremely interesting investigation of the spectrum of *Eta Carinæ,* a southern star whose violent fluctuations in brightness have made it an object of close attention for more than two centuries. The value of this study lies principally in its close connection with the general problem of new stars, inasmuch as *Eta Carinæ* has many of the characteristics of novæ, and is thought to have appeared originally as a nova.

Mr. MOORE has published a thorough investigation of the variable and spectroscopic binary star *Delta Cephei.*

The principal spectrographic observations at Mount Hamilton in the period covered by this report have had for their purpose the determination of the radial velocities of the planetary and certan other nebulæ, in continuation of Professor KEELER's visual observations of fourteen nebulæ with the 36-inch refractor in the years 1890-91. KEELER's observations showed that the Great Nebula in *Orion* is substantially at rest in space, as far as motion to or from the position occupied by our solar system is concerned, and that the planetary nebulæ are travelling rapidly. Studies of stellar velocities, as observed with the Mills spectrographs at Mount Hamilton and in Chile, had led to the important discovery in 1910 that the average stellar velocities increase with advancing spectral types. It was natural that the results for the stars should be compared with those available for the nebulæ; and it was found that the average velocities of the planetary nebulæ are very much higher than those of the stars supposedly young, and appreciably higher than those of the stars presumed to be oldest. As a result of these facts, serious doubt fell upon the generally accepted theory, dating back to the days of Sir WILLIAM HERSCHEL, that the stars in general are formed from planetary nebulæ by processes of evolution. It became important to observe the radial velocities of as great a number of the nebulæ as possible. More than one hundred nebular spectrograms have been secured for this purpose with the 36-inch refractor and a one-prism spectrograph in the past year, and occasional observations of the planetary nebulæ have been made in Chile during the past three years. We now have quite accurate determinations of the radial velocities of forty nebulæ altogether. They confirm the earlier results that planetary nebulæ are travelling with speeds far beyond those of the stars in general. The average radial velocity of the forty observed planetary nebulæ is in excess of 40 kilometers per second, whereas the average velocities of the stars vary from 6 kilometers per second for those supposedly youngest up to 17 kilometers per second for those supposedly oldest. The effect upon our ideas of the connection existing between planetary nebulæ and the stars is revolutionary; apparently the stars in general have not been evolved from planetary nebulæ.

It is of interest to note that one planetary nebula observed at Mount Hamilton has a velocity of recession amounting to approximately 150 kilometers per second, and that another planetary nebula observed at Santiago has a velocity of approach equal to 136 kilometers per second. Several nebulæ have velocities to or from us in excess of 60 kilometers per second.

In many other respects also the observations of nebulæ have assumed high importance, and it is intended to devote many of our resources to the subject during the coming year.

A considerable number of stellar spectrograms has been obtained with one-prism and three-prism dispersion at Mount Hamilton, in the past year, to supplement various phases of our stellar radial velocity program, and many minor studies of the spectrograms have been conducted by Dr. MOORE, Dr. PADDOCK, and Miss HOBE.

Seven comets have been observed for accurate position. In nearly all cases these observations have been used by the Berkeley Astronomical Department in computing the orbits of the comets concerned.

The Martin Kellogg Fellowship has been filled during the present year by Dr. ELI STUART HAYNES. His principal investigation concerns the well-known variable star SZ *Tauri*. A noted student of variable stars proposed the hypothesis that this star is of ellipsoidal form, and in rotation about one of its shorter axes, with the effect that maximum light occurs when the stars presents itself broadside to us, and minimum brightness when the longer axis points toward us. If this be the true cause of the observed variations and the star be single, the radial velocity of the star would be constant. Mr. HAYNES obtained twenty-nine spectrograms of the star, and his measures of them establish that the radial velocity is variable. The maximum brightness occurs when the star has the maximum velocity of approach, and the minimum brightness when the star has its maximum velocity of recession. These characteristics assign the object to the well-known Cepheid type of variation.

Mr. HAYNES has observed asteroid No. 694 on five nights and *Jupiter's* sixth satellite on five nights.

Mr. HAYNES has been appointed Associate Professor of Astronomy in Beloit College.

Mr. AITKEN conducted the astronomical classes in the Summer Session of 1913 in the University.

Mr. CAMPBELL represented the University at the meeting of the International Union for Co-operation in Solar Research at Bonn in July and August, 1913, and at the meeting of the Astronomische Gesellschaft at Hamburg in August, 1913.

The Director acknowledges the continued cordial support of the staff, both at Mount Hamilton and at Santiago, Chile.

Respectfully submitted,

W. W. CAMPBELL,
Director of the Lick Observatory.

MOUNT HAMILTON, June 1, 1914.